# SOUTHERN SEA OTTER (*Enhydra lutris nereis*)

U.S. Fish and Wildlife Service, Ventura, California

## STOCK DEFINITION AND GEOGRAPHIC RANGE

Southern sea otters are listed as threatened under the Endangered Species Act. They occupy nearshore waters along the mainland coastline of California from San Mateo County to Santa Barbara County (Figure 1). A small colony of southern sea otters also exists at San Nicolas Island, Ventura County, as a result of translocation efforts initiated in 1987. Under Public Law 99-625, the San Nicolas Island colony was formerly considered to be an experimental population (52 FR 29754; August 11, 1987), but the experimental population designation was removed upon termination of the translocation program and its respective translocation and management zones (77 FR 75266; December 19, 2012). With the termination of the translocation program, the special status afforded to southern sea otters within the management and translocation zones pursuant to Public Law 99-625 also ended.

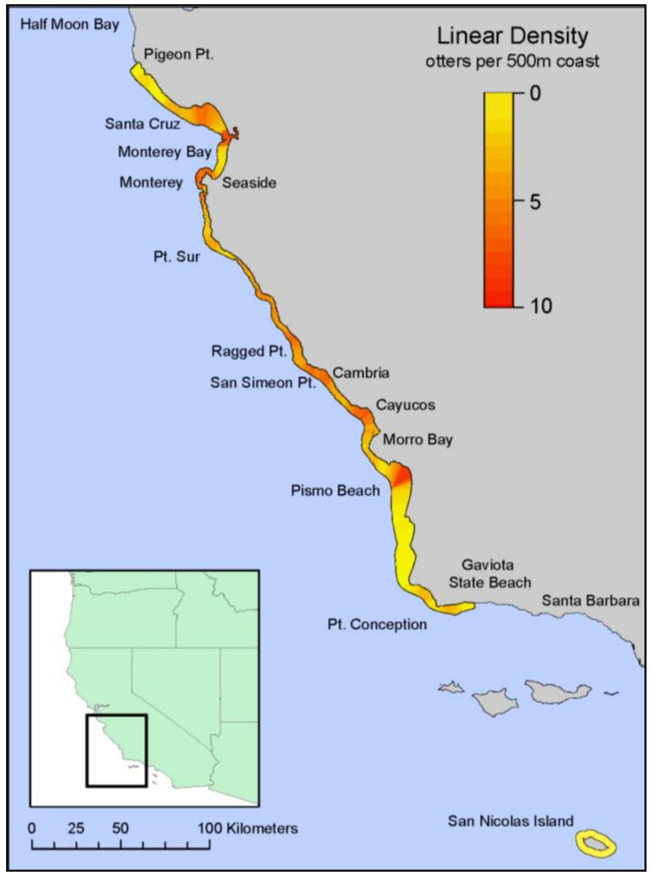


**Figure 1.** Current range of the southern sea otter (2013 census). Source: U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount

Historically, southern sea otters ranged from Punta Abreojos, Baja California, Mexico to Oregon (Valentine *et al.* 2008), or possibly as far north as Prince William Sound, Alaska (reviewed in Riedman and Estes 1990). During the 1700s and 1800s, the killing of sea otters for their pelts extirpated the subspecies throughout most of its range. A small population of southern sea otters survived near Bixby Creek in Monterey County, California, numbering an estimated 50 animals in 1914 (Bryant 1915). Since receiving protection under the International Fur Seal Treaty in 1911, southern sea otters have gradually expanded northward and southward along the central California coast. The estimated carrying capacity of California is approximately 16,000 animals (Laidre *et al.* 2001).

Sea otter abundance varies considerably across the range, with the highest densities occurring in the center part of the range (Monterey peninsula to Estero Bay), where sea otters have been present for the longest. Sea otter densities tend to be most stable from year-to-year in rocky, kelp-dominated areas that are primarily occupied by females, dependent pups, and territorial males. In contrast, sandy and soft-bottom habitats (in particular those in Monterey Bay, Estero Bay, and Pismo Beach to Pt. Sal) tend to be occupied by non-territorial males and sub-adult animals of both sexes (but rarely by adult females and pups) and are more variable in abundance from year to year.[1] This variation is apparently driven in part by the long-distance movements and seasonal redistribution of males (Tinker *et al.* 2006a). The variability of counts at the south end of the range is also related to seasonal movements: many males migrate to the range peripheries during the winter and early spring, apparently to take advantage of more abundant prey resources, but then return to the range center during the period when most breeding occurs (June to November) in search of estrous females (Jameson 1989, Ralls *et al.* 1996, Tinker *et al.* 2006a). Pupping of southern sea otters takes place year round, but a birth peak extending over several months occurs in the spring, and a secondary birth peak occurs in the fall (Siniff and Ralls 1991, Riedman *et al.* 1994).

All sea otters of the subspecies *Enhydra lutris nereis* are considered to belong to a single stock because of their recent descent from a single remnant population. Southern sea otters are geographically isolated from the other two recognized subspecies of sea otters, *E. l. lutris* and *E. l. kenyoni*, and have been shown to be distinct from these subspecies in studies of cranial morphology (Wilson *et al.* 1991) and variation at the molecular level (Sanchez 1992; Cronin *et al.* 1996; Larson *et al.* 2002).

## POPULATION SIZE

Data on population size have been gathered for more than 50 years. In 1982, a standardized survey technique was adopted to ensure that subsequent counts were comparable (Estes and Jameson 1988). This survey method involves shore-based censuses of approximately 60% of the range, with the remainder surveyed from the air. These surveys are conducted once each year (in spring). At San Nicolas Island, counts are conducted from shore (formerly quarterly, but semi-annually as of 2013). The highest of the counts is used as the official count for the year. In 2013, the official population index reported by the U.S. Geological Survey (2,941) included the 3-year running average for the mainland population (2,882) and the previous year's high count at San Nicolas Island (59). The 2011 mainland spring census was not completed due to weather conditions; therefore, the mainland 3-year running average is calculated from only the 2012 and 2013 raw counts (2,719 and 2,865, respectively) (U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount).

### Minimum Population Estimate

The minimum population estimate for the southern sea otter stock is taken as the lesser of the latest raw count or the latest 3-year running average for the mainland population, plus the count for San Nicolas Island. In 2013, the mainland count was 2,865. The 3-year running average was slightly higher, 2,882. Therefore, the minimum population estimate is 2,865 plus 59, or 2,924 animals.

### Current Population Trend

As recommended in the Final Revised Recovery Plan for the Southern Sea Otter (U.S. Fish and Wildlife Service 2003), 3-year running averages are used to characterize trends in the mainland population to dampen the effects of anomalous counts in any given year. Based on 3-year running averages of the annual spring counts, population performance along the mainland coastline has been mixed over the past several years, increasing between 2006 and 2008,

[1] Personal communication, M. Tim Tinker, 2008. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

decreasing between 2008 and 2010, and increasing again between 2010 and 2013 (Figure 2). The overall trend for the past 5 years has been essentially flat (0.16 percent), although this average growth rate masks considerable regional variation within the range. Growth of the colony at San Nicolas Island has averaged approximately 7.6 percent per year over the past 5 years (U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount).

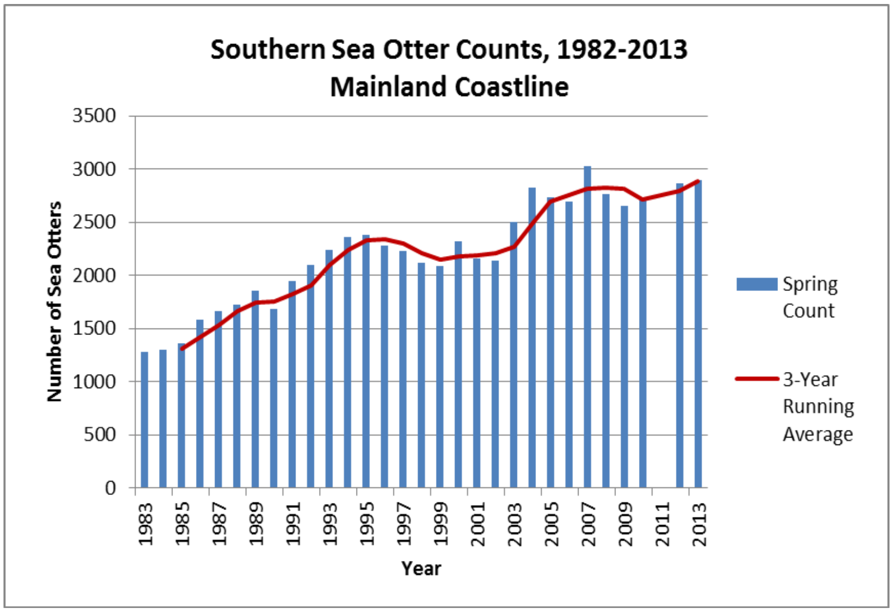


**Figure 2.** Southern sea otter counts 1983-2013 (mainland population). Data source: U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount.

## CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

We use the 5-year population trend to characterize current net productivity rates. As stated above, the average growth rate for this period is approximately 0.16 percent annually for the mainland population and approximately 7.6 percent annually for the San Nicolas Island population.

The maximum growth rate ($R_{max}$) for southern sea otters along the mainland coastline since the early 1980s (when reliable trend data first become available) appears to be 6 percent per year, although localized sub-populations have been observed to grow at much higher rates immediately after re-colonization.[2] In contrast, recovering or translocated populations at Attu Island, southeast Alaska, British Columbia, and Washington state all exhibited growth rates of up to 17 or 20 percent annually during the early stages of recovery (Estes 1990, Jameson and Jeffries 1999, Jameson and Jeffries 2005).

Although there has been speculation that the slower rate of population growth observed for the southern sea otter reflects some fundamental difference in survival or reproduction relative to northern sea otter populations, recent data and analyses call this assumption into question. First, a variety of evidence in recent years supports the conclusion that sea otters throughout much of central California are at or very near carrying capacity of the local environment, which explains the lack of growth in these areas (*i.e.*, further growth is limited by available food resources) (Tinker *et al.* 2006b, Tinker *et al.* 2008). Second, radio-tagging studies report age- and sex-specific rates of survival and reproduction that are comparable for southern sea otters and northern sea otters, at least when status with respect to carrying capacity is controlled for (Monson *et al.* 2000, Tinker *et al.* 2006b). Finally, recent modeling analyses

[2] Personal communication, M. Tim Tinker, 2013. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

indicate that the spatial configuration of available habitat (the long narrow strip of coastal shelf characteristic of California versus the bays, islands, and complex matrices of inland channels characteristic of the habitat in Washington, British Columbia, and Alaska), combined with the high degree of spatial structure in sea otter populations (due to limited mobility of reproductive females), will result in greatly different expected population growth rates over the long term, and may account in large part for the differences in trends between the southern sea otter and northern sea otter populations.[3]

From the early 1900s to the mid-1970s, the southern sea otter population is thought to have increased at about 5 percent annually (Estes 1990), although consistent surveys and trend data from early years are lacking. From 1983 to 1995, annual growth averaged about 6 percent. The population declined during the late 1990s, resumed growth in the early 2000s, and ceased growth again beginning in 2008. Growth rates at San Nicolas Island averaged approximately 9 percent annually from the early 1990s to the mid-2000s and approximately 7.6 percent over the past 5 years.

## POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of three elements: the minimum population estimate ($N_{min}$); half the maximum net productivity rate (0.5 $R_{max}$); and a recovery factor ($F_r$). This can be written as: PBR = ($N_{min}$) (½ of $R_{max}$)($F_r$ ).

For the southern sea otter stock, $N_{min}$ = 2,924, $R_{max}$ = 6 percent, and $F_r$ = 0.1. A recovery factor of 0.1 is used for the southern sea otter stock because, although the population appears to be stable, Nmin is below 5,000, and the species is vulnerable to a natural or human-caused catastrophe, such as an oil spill, due to its restricted geographic distribution in nearshore waters (Taylor *et al.* 2002). Therefore, the PBR for the southern sea otter stock is 8.77, which when rounded down to the nearest whole animal is 8. It is important to note that take of southern sea otters incidental to commercial fishing operations cannot be authorized under the MMPA. Thus, the provisions governing the authorization of incidental take in commercial fisheries at MMPA Sections 101(a)(5)(E) and 118, which include requirements to develop take reduction plans with the goal of reducing incidental mortality or serious injury of marine mammals to levels less than the PBR, do not apply with respect to southern sea otters.

## HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

### Fishery Information

Sea otters are susceptible to entanglement and drowning in gill nets. The set gill net fishery in California is estimated to have killed from 48 to 166 (average of 103) southern sea otters per year from 1973 to 1983 (Herrick and Hanan 1988) and 80 sea otters annually from June 1982 to June 1984 (Wendell *et al.* 1986). A 1991 closure restricted gill and trammel nets to waters deeper than 30 fathoms (55 meters) throughout most of the southern sea otter’s range (California Senate Bill No. 2563). In 1990, NMFS started an observer program using at-sea observers, which provided data on incidental mortality rates relative to the distribution of fishing effort. The observer program was active through 1994, discontinued from 1995 to 1998, and reinstated in the Monterey Bay area in 1999 and 2000 because of concern over increased harbor

[3] Personal communication, M. Tim Tinker, 2013. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

porpoise mortality. Based on a detailed analysis of fishing effort, sea otter distributions by depth, and regional entanglement patterns during observed years, NMFS estimated southern sea otter mortality in the halibut set gill net fishery to have been 64 in 1990, zero from 1991 to 1994, 3 to 13 in 1995, 2 to 29 in 1996, 6 to 47 in 1997, 6 to 36 in 1998, 5 in 1999, and zero in 2000 (Cameron and Forney 2000; Carretta 2001; Forney *et al.* 2001). The increase in estimated mortality from 1995 to 1998 was attributed to a shift in set gill net fishing effort into areas where sea otters are found in waters deeper than 30 fathoms (55 meters).

Fishing with gill nets has since been further restricted throughout the range of the southern sea otter. An order prohibiting the use of gill and trammel nets year-round in ocean waters of 60 fathoms or less from Point Reyes, Marin County, to Point Arguello, Santa Barbara County was made permanent in September 2002. In the waters south of Point Arguello, the Marine Resources Protection Act of 1990 (California Constitution Article 10B) defined a Marine Resources Protection zone in which the use of gill and trammel nets is banned. This zone includes waters less than 70 fathoms (128 meters) or within one nautical mile (1.9 kilometers), whichever is less, around the Channel Islands, and waters generally within three nautical miles (5.6 kilometers) offshore of the mainland coast from Point Arguello to the Mexican border. Although sea otters occasionally dive to depths of 328 feet (100 meters), the vast majority (>99 percent) of dives are to depths of 131 feet (40 meters) or less.[4] Because of these restrictions and the current extent of the southern sea otter's range, southern sea otter mortalities resulting from entanglement in gill nets are likely to be at or near zero. Nevertheless, sea otters may occasionally transit areas that are not subject to closures, and levels of observer coverage of gill and trammel net fisheries are insufficient to confirm an annual incidental mortality and serious injury rate of zero in these fisheries (see Table 1) (Barlow 1989, Babcock *et al.* 2003). An estimated 50 vessels participate in the CA halibut/white seabass and other species set gillnet (>3.5" mesh) fishery (78 FR 53336, August 29, 2013). Approximately 30 vessels participate in the CA yellowtail, barracuda, and white seabass drift gillnet fishery (mesh size ≥3.5" and <14") (78 FR 53336, August 29, 2013). Approximately 25 vessels participate in the CA thresher shark/swordfish drift gillnet fishery (≥14" mesh) (78 FR 53336, August 29, 2013).

Three southern sea otter interactions with the California purse seine fishery for Northern anchovy and Pacific sardine have been documented. In 2005, a contract observer in the NOAA Fisheries California Coastal Pelagic Species observer program documented the incidental, non-lethal capture of two sea otters that were temporarily encircled in a purse seine net targeting Northern anchovy but escaped unharmed by jumping over the corkline. In 2006, a contract observer in the same program documented the incidental, non-lethal capture of a sea otter in a purse seine net targeting Pacific sardine. Again, the sea otter escaped the net at end of the haul without assistance.[5] Based on these observations and the levels of observer coverage in each year, 58 and 20 such interactions are estimated to have occurred in the CA sardine purse seine fishery in 2005 and 2006, respectively, but these estimates are accompanied by considerable uncertainty because of the low levels of observer coverage.[6] There are no data available to assess whether sea otter interactions with purse-seine gear are currently resulting in mortality or

[4] Personal communication, M. Tim Tinker, 2008. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

[5] Personal communication, Lyle Enriquez, 2006. Southwest Regional Office, NOAA, U.S. National Marine Fisheries Service, 501 West Ocean Boulevard, Long Beach, CA 90802.

[6] Personal communication, Jim Carretta, 2008. Southwest Fisheries Science Center, NOAA, U.S. National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

serious injury. The 2007 list of fisheries reorganized purse seine fisheries targeting anchovy and sardines into the "CA anchovy, mackerel, sardine purse seine" fishery. An estimated 65 vessels participate in the CA anchovy, mackerel, and sardine purse seine fishery (78 FR 53336, August 29, 2013).

The potential exists for sea otters to drown in traps set for crabs, lobsters, and finfish, but only limited documentation of mortalities is available. Hatfield and Estes (2000) summarize records of 18 sea otter mortalities in trap gear, 14 of which occurred in Alaska. With the exception of one sea otter, which was found in a crab trap, all of the reported Alaska mortalities involved Pacific cod traps and were either recorded by NMFS observers or reported to NMFS observers by fishers. Four sea otters are known to have died in trap gear in California: one in a lobster trap near Santa Cruz Island in 1987; a mother and pup in a trap with a 10-inch diameter opening (presumed to be an experimental trap) in Monterey Bay in 1987; and one in a rock crab trap 0.5 miles off Pt. Santa Cruz, California (Hatfield and Estes 2000). In 1995, the U.S. Geological Survey began opportunistic efforts to observe the finfish trap fishery in California. These efforts were supplemented with observations by the California Department of Fish and Game (CDFG) in 1997 and two hired observers in 1999. No sea otters were found in the 1,624 traps observed (Hatfield and Estes 2000). However, a very high level of observer coverage would be required to see any indication of trap mortality, even if mortality levels were high enough to substantially reduce the rate of population growth (Hatfield *et al.* 2011).

Controlled experiments conducted by the U.S. Geological Survey and the Monterey Bay Aquarium demonstrated that sea otters would enter a baited commercial finfish trap with inner trap funnel openings of 5.5 inches in diameter (Hatfield and Estes 2000). Hatfield *et al.* (2011) confirmed that some sea otters exposed to finfish, lobster, and mock Dungeness crab traps in a captive setting would succeed in entering them. Based on experiments with carcasses and live sea otters, they concluded that finfish traps with 5-inch-diameter circular openings would largely exclude diving sea otters; that circular openings of 5.5 to 6 inches in diameter and rectangular openings 4 inches high (typical of Dungeness crab pots) would allow the passage of sea otters up to about 2 years of age; and that the larger fyke openings of spiny lobster pots and finfish traps with openings larger than 5 inches would admit larger sea otters. Reducing the fyke-opening height of Dungeness crab traps by one inch (to 3 inches) would exclude nearly all diving sea otters while not significantly affecting the number or size of harvested crabs (Hatfield *et al.* 2011). Since January 2002, CDFG has required 5-inch sea-otter-exclusion rings to be placed in live-fish traps used along the central coast from Pt. Montara in San Mateo County to Pt. Arguello in Santa Barbara County. No rings are required for live-fish traps used in the waters south of Point Conception, and no rings are currently required for lobster or crab traps regardless of their location in California waters. Estimates of the number of vessels participating in pot and trap fisheries off California are given in parentheses: CA Dungeness crab pot (534); CA coonstripe shrimp, rock crab, tanner crab pot or trap (305); CA spiny lobster (225); and CA nearshore finfish live trap/hook-and-line (93) (78 FR 53336, August 29, 2013).

Available information on incidental mortality and serious injury of southern sea otters in commercial fisheries is very limited. Due to the lack of observer coverage, a reliable, science-based estimate of the annual rate of mortality and serious injury cannot be determined. Commercial fisheries believed to have the potential to kill or injure southern sea otters are listed in Table 1. Due to the nature of potential interactions (entrapment or entanglement followed by drowning), serious injury is unlikely to be detected prior to the death of the animal.

**Table 1.** Summary of available information on incidental mortality and serious injury of southern sea otters in commercial fisheries that have the potential to interact with southern sea otters.

| Fishery Name | Year(s) | Number of Vessels[1] | Data Type | Percent Observer Coverage[2] | Observed Mortality/ Serious Injury | Estimated Mortality/ Serious Injury | Mean Annual Mortality/ Serious Injury |
|---|---|---|---|---|---|---|---|
| CA halibut/white seabass and other species set gillnet (>3.5”) | 2008<br>2009<br>2010<br>2011<br>2012 | 50 | observer<br>n/a<br>observer<br>observer<br>observer | 17.8%<br>not observed<br>12.5%<br>8%<br>5.5% | 0<br>n/a<br>0<br>0<br>0 | n/a | n/a |
| CA yellowtail, barracuda, and white seabass drift gillnet (≥3.5” and <14”) | 2008<br>2009<br>2010<br>2011<br>2012 | 30 | n/a<br>n/a<br>n/a<br>observer<br>observer | not observed<br>not observed<br>not observed<br>3.3%<br>0.7% | n/a<br>n/a<br>n/a<br>0<br>0 | n/a | n/a |
| CA thresher shark/swordfish drift gillnet fishery (≥14”) | 2008<br>2009<br>2010<br>2011<br>2012 | 25 | observer | 13.5%<br>13.3%<br>11.9%<br>19.5%<br>18.6% | 0<br>0<br>0<br>0<br>0 | n/a | n/a |
| CA anchovy, mackerel, and sardine purse seine | 2008<br>2009<br>2010<br>2011<br>2012 | 65 | observer<br>n/a<br>n/a<br>n/a<br>n/a | ~5%<br>not observed<br>not observed<br>not observed<br>not observed | 0<br>n/a<br>n/a<br>n/a<br>n/a | n/a | n/a |
| CA Dungeness crab pot | 2008<br>2009<br>2010<br>2011<br>2012 | 534 | n/a | not observed | n/a | n/a | n/a |
| CA coonstripe shrimp, rock crab, tanner crab pot or trap[3] | 2008<br>2009<br>2010<br>2011<br>2012 | 305 | n/a | not observed | n/a | n/a | n/a |
| CA spiny lobster[3] | 2008<br>2009<br>2010<br>2011<br>2012 | 225 | n/a | not observed | n/a | n/a | n/a |
| CA nearshore finfish live trap/hook and line[3] | 2008<br>2009<br>2010<br>2011<br>2012 | 93 | n/a | not observed | n/a | n/a | n/a |
| Unknown hook and line | 2008<br>2009<br>2010<br>2011<br>2012 | n/a | stranding data | — | 0<br>0<br>0<br>0<br>0 | ≥0 | ≥0 |
| Unknown net | 2008<br>2009<br>2010<br>2011<br>2012 | n/a | stranding data | — | 0<br>0<br>0<br>1[4]<br>0 | ≥1 | ≥0.2 |

Note: n/a indicates that data are not available or are insufficient to estimate mortality/serious injury.
[1] Vessel numbers are from the final List of Fisheries for 2013 (78 FR 53336, August 29, 2013).
[2] Personal communication, Jim Carretta, 2010, 2011, 2013. Southwest Fisheries Science Center, NOAA, U.S. National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.
[3] This fishery is classified as a Category III fishery (78 FR 53336, August 29, 2013). Category III fisheries are not required to accommodate observers aboard vessels due to the remote likelihood of mortality and serious injury of marine mammals.
[4] This sea otter was also shot, apparently after becoming entangled in the net.

**Other Mortality**

Variation in reproductive success and survival rates of sea otters in central California appears to be influenced primarily by density-dependent resource limitation (Tinker 2013). Physiological condition and nutritional status in turn influence the susceptibility of sea otters to environmental stressors (including pathogens, pollutants, and intoxicants produced during harmful algal blooms), which may result in death by a variety of proximate causes, including infectious disease, intra-specific aggression, intoxication, and other pathological conditions (Tinker 2013).

Common causes of death identified for fresh beach-cast carcasses necropsied from 1998 to 2001 included protozoal encephalitis, acanthocephalan-related disease, shark attack, and cardiac disease (Kreuder *et al.* 2003, Kreuder *et al.* 2005). Encephalitis caused by *Toxoplasma gondii* was associated with shark attack and heart disease (Kreuder *et al.* 2003). Diseases (due to parasites, bacteria, fungi, or unspecified causes) were identified as the primary cause of death in 63.8 percent of the sea otter carcasses examined (Kreuder *et al.* 2003). Unusually high numbers of stranded southern sea otters were recovered in 2003, prompting declaration of an Unusual Mortality Event for the period from 23 May to 1 October 2003. The increase in strandings was not attributable to any one cause, although intoxication by domoic acid produced by blooms of the alga *Pseudonitzchia australis* is believed to have been an important contributor (Jessup *et al.* 2004).

From 2008 through 2012, the number of strandings relative to the spring count averaged 10.4 percent (Figure 3; the entry for 2011 is missing because the spring survey was not completed that year). However, relative strandings have increased sharply over this period, with record highs in 2010 and 2012, 11.2 and 12.8 percent of the spring count, respectively (U.S Geological Survey unpublished data). These spikes in relative strandings appear to be due largely to an upswing in shark bite mortality in the northern and southern portions of the range (north of Seaside and, most markedly, south of Cayucos) (Tinker *et al.* 2013). Increasing shark-bite mortality is also a longer-term trend. The proportion of sea otter deaths caused by shark bites has increased 4-fold over the last 20 years and accounts for 45 percent of the variation in population trends during this period (Tinker *et al.* 2013). The reasons for the increase in shark bite mortality are unknown.

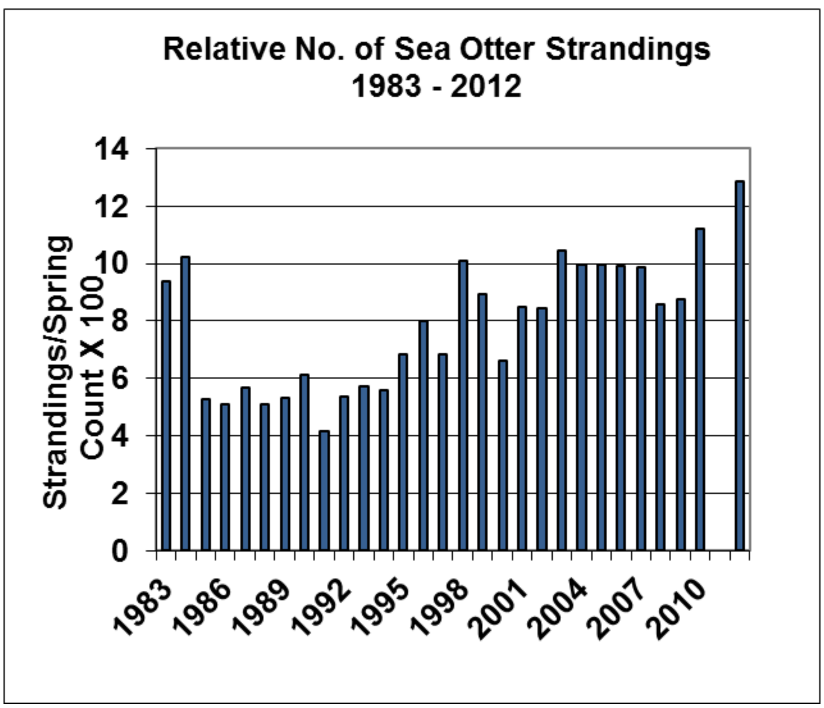


**Figure 3.** Strandings of southern sea otters relative to the spring count, 1983-2012. The entry for 2011 is missing because the spring survey was not completed that year. Source: U.S. Geological Survey unpublished data.

Non-fishery-related anthropogenic mortality of sea otters is a result of indirect and direct causes. The ocean discharge of freshwater microcystins (persistent biotoxins produced by cyanobacteria of the genus *Microcystis*, which can form toxic blooms under conditions of elevated nutrient concentration, salinity, and temperature), has been linked to the deaths of more than 30 sea otters (through 2012), with the earliest known case occurring in 1999 and the greatest number of cases occurring in 2007 (Miller *et al.* 2010; CDFG unpublished data). Boat strikes typically cause several deaths each year. Shootings are a relatively low but persistent source of anthropogenic mortality. Other rare sources of anthropogenic mortality include debris entanglement and complications associated with research activities. Stranding data indicate that during the period from 2008 through 2012, at least 10 sea otters died of microcystin intoxication, 2 were shot[7], 12 were suspected to have been struck by boats, 1 was entangled in debris, and 3 died as a result of complications related to research activities (U.S. Geological Survey and CDFG unpublished data). Total observed anthropogenic mortality from 2008-2012, excluding any fisheries-related mortality, is 28, yielding an estimated mortality of ≥28 and a mean annual mortality of ≥5.6. Disease is an important proximate cause of death in sea otters, but due to several complicating factors (including the complexity of the pathways by which sea otters are being exposed to land-borne pathogens, the synergistic relationship between sea otter susceptibility to disease and density-dependent resource limitation, and other factors), the anthropogenic contribution to disease-related mortality in sea otters is not well understood. Therefore, animals that died of disease (other than acute liver failure resulting from microcystin poisoning) are not included in the anthropogenic mortalities reported here.

It should be noted that the mean annual mortality/serious injury reported here and in Table 1 are minimum estimates.[8] Documentation of these sources of mortality comes primarily from necropsies of beach-cast carcasses, which constitute a subset (roughly half) of all dead southern sea otters and likely do not represent an unbiased sample with respect to cause of death because carcass deposition and retrieval are dependent on carcass size, location, wind, currents and other factors, including the cause of death itself (Gerber *et al.* 2004, Tinker *et al.* 2006a). Within this subset, the cause of death of many recovered carcasses is unknown, either because the carcass is too decomposed for examination or because cause of death cannot be determined (Gerber *et al.* 2004).[9] Because it is unknown to what extent the levels of human-caused mortality documented in beach-cast carcasses are representative of the relative contributions of known causes or of human-caused mortality as a whole, we are unable to give upper bounds for these estimates.

## STATUS OF STOCK

The southern sea otter is designated a fully protected mammal under California State law (California Fish and Game Code §4700) and was listed as a threatened species in 1977 (42 FR 2965) pursuant to the federal Endangered Species Act, as amended (16 U.S.C. 1531 et seq.). As a consequence of its threatened status, the southern sea otter is considered to be a "strategic stock" and "depleted" under the MMPA.

[7] An additional animal, not included in this total, was also shot, apparently after becoming entangled in a net (fishery unknown).
[8] This statement applies to all causes of death mentioned here except research-related mortalities. Research-related mortalities are unlikely to be undetected because of the intensive monitoring that tagged sea otters receive.
[9] In 2012, the cause of death of approximately 35 percent of recovered carcasses was unknown. Personal communication, Brian Hatfield, 2013. Wildlife Biologist, USGS-Western Ecological Research Center, Hwy. 1, P.O. Box 70. San Simeon, CA 93452.

The status of the southern sea otter in relation to its optimum sustainable population (OSP) level has not been formally determined, but population counts are well below the estimated lower bound of the OSP level for southern sea otters, about 8,400 animals (U.S. Fish and Wildlife Service 2003), which is roughly 50 percent of the estimated carrying capacity of California (Laidre *et al.* 2001). Because of the lack of observer data for several commercial fisheries that may interact with sea otters, it is not possible to make a science-based determination of whether the total mortality and serious injury of sea otters due to interactions with commercial fisheries is insignificant and approaching a zero mortality and serious injury rate.

**Habitat Issues**

Sea otters are particularly vulnerable to oil contamination (Kooyman and Costa 1979; Siniff *et al.* 1982), and oil spill risk from large vessels that transit the California coast remains a primary threat to the southern sea otter. Studies of contaminants have documented accumulations of dichlorodiphenyltrichloro-ethane (DDT), dichlorodiphenyl-dichloroethylene (DDE) (Bacon 1994; Bacon *et al.* 1999), and polychlorinated biphenyls (PCBs) in stranded sea otters (Nakata *et al.* 1998), as well as the presence of butyltin residues, which are known to be immunosuppressant (Kannan *et al*. 1998). Kannan *et al.* (2006, 2007) found a significant association between infectious diseases and elevated concentrations of perfluorinated contaminants and polychlorinated biphenyls (PCBs) in the livers of sea otters, suggesting that chemical contaminants may influence patterns of sea otter mortality. Harmful algal blooms are increasingly recognized as a source of mortality (*e.g.*, Miller *et al.* 2010). Food limitation and nutritional deficiencies appear to be the primary driver of sea otter mortality (particularly in the central portion of the range from Seaside to Cayucos), either directly or as a consequence of dietary specialization (by increasing the exposure to protozoal pathogens of sea otters that specialize on non-preferred prey types) (Bentall 2005, Tinker *et al.* 2006b, Tinker *et al.* 2008, Johnson *et al.* 2009, Tinker 2013). Changes in the carbonate chemistry of the oceans due to increasing atmospheric $CO_2$ levels (ocean acidification) may pose a serious threat to marine organisms, particularly calcifying organisms (Kroeker *et al.* 2010, Kurihara *et al.* 2008, Stumpp *et al.* 2011), many of which are important prey for sea otters. However, effects on sea otters will depend on numerous factors (such as potential ecological shifts arising from variable responses among marine organisms) that cannot currently be predicted.

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